

Long Life Miniature Hall Thruster Enabling Low Cost Human Precursor Missions

Completed Technology Project (2013 - 2016)



Project Introduction

Key and Central Objectives: This investigation aims to demonstrate that the application of magnetic shielding technology on miniature Hall thrusters will dramatically improve the operational life of these devices while improving total efficiency and performance. By applying magnetically shielded field topography to a custom-built miniature Hall thruster, we will show that erosion and localized heating problems are eliminated when compared to a non-shielded design. This will allow the device to operate at its optimum discharge voltage without the negative effects of discharge channel erosion or high-energy electron power deposition, thereby increasing operational life, increasing total efficiency, and improving thruster performance. **Significance of Objectives:** This novel miniature Hall thruster will enable low cost deep space human precursor missions to near Earth asteroids (NEAs), near Earth objects (NEOs), and nearby planets. As discussed in the NASA In-Space Propulsion System Roadmap Section 2.2.1.2.2, the development of high-power Hall thrusters with longer operational lifetimes is necessary for human missions throughout the solar system. Before such missions can occur, however, precursor missions involving low cost miniature spacecraft must survey the target NEA, NEO, or planet to mitigate the risks of deep space human travel. Employing long life, high efficiency miniature Hall thrusters on such precursor spacecraft will enable shorter mission times due to the increased thrust (compared to ion thrusters) while maintaining the high propellant efficiency common to electric propulsion devices. **Proposed Method/Techniques:** This effort will combine experimental and computational approaches to determine an efficient and robust thruster design. Initial modeling efforts will be used before testing to design the thruster's magnetic circuit, feed system, and plasma channel. Models will also be used throughout the testing and post-test analysis to assess thruster performance and associated plasma behavior. The experimental aspect of this investigation requires the construction of two nearly identical miniature Hall thrusters. The first custom thruster will be built using conventional Hall thruster designs (purely radial magnetic field near the thruster channel exit). This thruster will be rigorously tested and all of its performance and efficiency data will be recorded. These data are expected to be on the same order of the performance and efficiency of the state-of-the-art BHT-200 and will be the control for this experiment. The second thruster will employ magnetically shielded field topography for a miniature thruster based on the design principles discussed by Hofer and Mikellides, et al. This device will be tested in the same way as the first thruster to provide a direct comparison of performance and efficiency. All experiments are to be carried out in the newly constructed Pi Facility vacuum chamber (5' diameter x 9' length) at UCLA, capable of $5\text{e-}7$ Torr base pressure. A direct comparison of the data from the two test thrusters will demonstrate the benefits of magnetic shielding 'in miniature Hall thrusters. The physical mechanisms responsible for the improvements in performance due to shielding will be illuminated and explained by plasma diagnostics data. Successful completion of this investigation will result in demonstrating the elimination of discharge channel



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Table of Contents

Project Introduction	1
Organizational Responsibility	1
Anticipated Benefits	2
Primary U.S. Work Locations and Key Partners	2
Project Management	2
Technology Maturity (TRL)	2
Technology Areas	2
Project Website:	3

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Space Technology Research Grants

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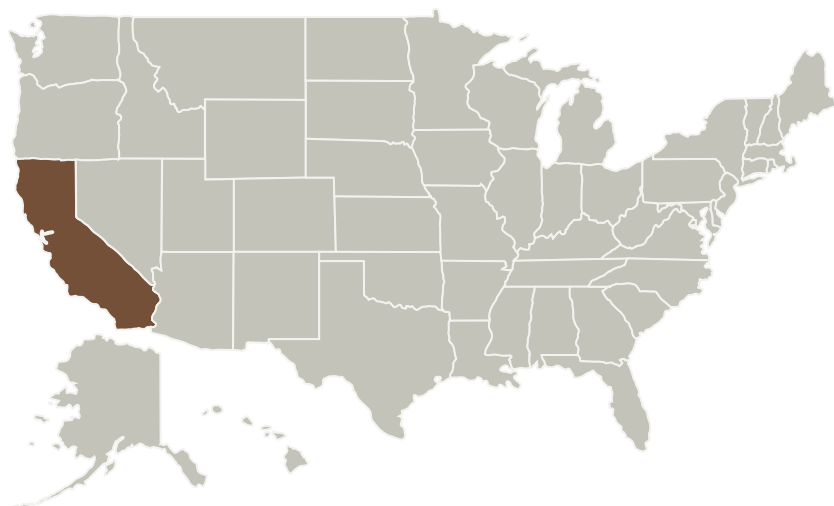


wall erosion as a life limiting factor for miniature Hall thrusters along with improved performance and efficiency through the application of the magnetic shielding techniques.

Anticipated Benefits

This novel miniature Hall thruster will enable low cost deep space human precursor missions to near Earth asteroids (NEAs), near Earth objects (NEOs), and nearby planets. As discussed in the NASA In-Space Propulsion System Roadmap Section 2.2.1.2.2, the development of high-power Hall thrusters with longer operational lifetimes is necessary for human missions throughout the solar system. Before such missions can occur, however, precursor missions involving low cost miniature spacecraft must survey the target NEA, NEO, or planet to mitigate the risks of deep space human travel. Employing long life, high efficiency miniature Hall thrusters on such precursor spacecraft will enable shorter mission times due to the increased thrust (compared to ion thrusters) while maintaining the high propellant efficiency common to electric propulsion devices.

Primary U.S. Work Locations and Key Partners



Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

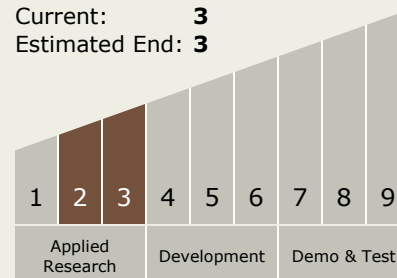
Richard E Wirz

Co-Investigator:

Ryan W Conversano

Technology Maturity (TRL)

Start: 2
Current: 3
Estimated End: 3



Technology Areas

Primary:

- TX01 Propulsion Systems
 - └ TX01.2 Electric Space Propulsion
 - └ TX01.2.2 Electrostatic

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Organizations Performing Work	Role	Type	Location
University of California-Berkeley(Berkeley)	Supporting Organization	Academia	Berkeley, California
University of Southern California(USC)	Supporting Organization	Academia	Los Angeles, California

Primary U.S. Work Locations

California

Project Website:

<https://www.nasa.gov/directorates/spacetech/home/index.html>